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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in VTOL Aircraft

We, GENERAL ELECTRIC COMPANY, a Corporation organized and existing under the laws of the State of New York, United States of America, residing at 1 River Road, Schenectady 5, New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a VTOL or vertical take-off and landing aircraft which uses fans in the wings for both horizontal propulsion and lift permitting efficient hovering and high horizontal speed.

The VTOL, or vertical take-off and landing aircraft has assumed many types over the past few years. With the advent of the jet propulsion engine, VTOL aircraft employing such engines have been studied and produced. The advantage of the VTOL aircraft is obvious since it dispenses with long runways and permits a much more maneuverable craft. Some proposals disclose aircraft on which the jet engines are rotatable on the wing tips so that they may exhaust directly downwardly for vertical lift and then be rotated into a horizontal position for horizontal flight. Others use large fans in the wings which move large quantities of air through ducts in the wings from the top surface to the bottom surface of the wings to produce lift and, by means of louvers, direct the air rearwardly to provide horizontal thrust for transition from vertical flight to horizontal flight. These fans are powered by powerplants such as jet propulsion engines which may direct exhaust through ducts to tip turbine blades mounted on the fans, or may drive the fans directly by mechanical linkage means. The fans move a large quantity of air to provide a lift force but the aircraft is relatively slow moving in the horizontal direction as long as the lift fans are being driven by the jet propulsion engines.

An aircraft is desired which is able to take-off in a vertical direction, hover, and move forward at relatively high speeds without switching from one engine or set of engines to another. To provide the necessary lift in a VTOL aircraft, large fans are required which if mounted in the fuselage leave little room for carrying a pay load of either freight or passengers. When the lift fans are mounted in the aircraft wings, a problem is created due to the lift fan mounting requirements whereby the wings of a VTOL aircraft are larger and thicker than those of a conventional aircraft. In addition, the fan-in-wing aircraft when moving in a horizontal direction are susceptible to distortion of the air flow across the wing due to the fan discharge.

The object of the present invention is to provide a VTOL aircraft using wing mounted fans for both vertical and horizontal flight, wherein the disadvantages normally associated with the large wing required for fan accommodation are overcome by reducing the wing drag, and wherein the distortion of air flow over the wing engendered by the fan discharge is obviated.

According to the present invention, a VTOL aircraft having a fuselage with wings extending therefrom, each wing being formed with a duct having a rearwardly extending portion provided with an air inlet in the leading edge of the wing and a louvered outlet in the lower surface of the wing, each duct having a driven fan disposed adjacent to the downstream end thereof, each duct is formed with an additional louvered air inlet in the top surface of the wing, and a recess is provided in each of the lower wing surfaces extending rearwardly from the duct outlet into which the respective ducts exhaust during horizontal flight when the louvered openings in the upper wing surface are closed and the louvers in the duct outlet deflect the fan

exhaust rearwardly. Reaction means may be disposed in the fuselage at the tail of the aircraft to discharge fluid selectively to control the yaw of the aircraft. Moreover, a trim fan may be disposed in the fuselage forwardly of the wing fans to discharge air taken through an inlet in the fuselage leading surface, downwardly through an opening in the lower surface of the fuselage.

Fan driving means may be provided before the gas turbine engine or engines located in the fuselage of the aircraft and coupled to the wing fans and trim fan.

In the accompanying diagrammatic drawings,

Fig. 1 is a plan view of an aircraft employing the present invention and showing some parts in dotted lines.

Fig. 2 is a front elevational view of the aircraft showing the air inlets

Fig. 3 is a side elevation, partially in section, showing the air flow paths during take-off and hovering.

Fig. 4 is a view, similar to Fig. 3 showing the air flow paths during horizontal flight and,

Fig. 5 is a schematic view of a typical reaction control mechanism.

Referring first to Fig. 1, there is shown an aircraft having a fuselage 10 and wings 11 extending from the fuselage on either side thereof. The fuselage is equipped with a conventional T-tail type tail unit 12 which is used for control during horizontal flight.

In order to provide motive power, both for vertical lift and horizontal flight, each wing 11 is provided with a through duct having a rearwardly extending portion and a downwardly extending portion generally indicated at 13 as seen in Fig. 3 through which air is designed to move in large low pressure quantities. Each duct 13 has a forwardly directed inlet 14 in the leading edge of the wing for a purpose to be explained. In addition, each duct 13 has an additional opening 15 in the upper surface of the wing. In order to control the opening 15, suitable louvers 16 are provided therein and these are pivoted by any suitable means to control air flow between an open position as shown in the hovering condition in Fig. 3 and a closed smooth surface position as shown in horizontal flight in Fig. 4. Each duct 13 terminates in a rearwardly extending recessed portion 17 as shown in Figs. 3 and 4, in the lower surface of the wing. The purpose of this recess will be explained hereinafter. Disposed in the outlet of duct 13 is a further set of control louvers 18 which are pivoted in a suitable manner to direct air flow downwardly as shown in Fig. 3 or rearwardly as shown in Fig. 4.

In order to move large quantities of low pressure air through the rearwardly and downwardly extending duct 13, fan 19 is provided in the duct toward the downstream end of the

duct. The fan 19 is mounted on an axis that is inclined to the horizontal but which may be mounted on a vertical axis. The disposition of the fan will depend on wing size and shape. Fan 19 may consist of a single fan with blades 20 supported by struts 21 or may employ contra-rotating fans not shown.

In order to drive the fan 19, there is provided, as seen in Fig. 1, within the fuselage 10, suitable driving means 22 which may conveniently take the form of a gas turbine engine or engines, as diagrammatically shown at 23, in the vertical position. It will be obvious that driving means 22 may take a number of suitable forms of which the gas turbine engine is merely illustrative. The fans are connected to the fuselage mounted driving means by suitable linkage 24 which may diagrammatically represent either a duct to direct the exhaust gases to tip turbine blades secured to the circumference of the fans, or hydraulic connections, or mechanical linkage connected to a gearing mechanism as shown at 25 to drive the fans. The latter arrangement may be generally preferred although the duct arrangement driving tip turbine fans is the desired embodiment of the invention. The schematic showing in Fig. 1 is intended to cover these driving connection alternatives.

The gas turbines 23 within the fuselage may obtain their air supply through scoop 26 mounted on the fuselage top and ducting the air to the engines.

Depending on the location of the center of gravity of the aircraft, and it is assumed in the present illustration that it is substantially ahead of the center of lift of the wing fans as shown in Fig. 3, it is necessary to provide trim means to balance the attitude of the aircraft while in the hovering position. To this end, a trim fan 30 is provided in the forward portion 27 of the aircraft ahead of the wing fans 19. The trim fan is mounted in a duct 28 as shown, the duct having a forwardly directed inlet and discharging downwardly through pivotable control louvers 29. It is important that fan 30 moves the air through duct 28 to discharge it in the downward direction and contribute to the lift of the aircraft. The proper placement of the trim fan with respect to the center of gravity permits it always to discharge downwardly thus contributing to lift at all times during hovering of the aircraft. Trim fan 30 may be driven from driving means 22 by any suitable linkage means as shown in Fig. 1 by the dotted lines as a representative linkage 31 interconnecting the two.

In order to control yaw of the aircraft, there is provided a reaction means generally indicated at 32 and preferably located aft of the wing fans in the tail of the aircraft. The reaction means may take any suitable form such as a shutter arrangement for directing control jets outwardly of the aircraft tail.

Alternatively, it may take a simple form as shown in Fig. 5 which illustrates a chamber 33 having an air fluid inlet pipe 34. Nozzles 35 are selectively controlled by valve 36 as
 5 actuated by linkage 37. This is merely another illustrative embodiment of a typical reaction means 32 that may be selectively used to control yaw. These reaction means may
 10 operate with bleed air or exhaust gases from the main engines. A separate source of fluid flow may also be provided.

The operation during hovering is as shown in Fig. 3 wherein all louvers are open with control louvers 18 and 29 directing the air
 15 downwardly. Through inlet 14 and by opening inlet 15, large quantities of low pressure air are propelled to pass through the fan which is necessary during the lifting phase.

During horizontal flight, the louvers 16 and 29 are closed, as in Fig. 4, to provide a smooth aerodynamic surface and the reduced
 20 air flow required for horizontal flight is taken aboard through the forwardly directed opening 14 and discharged rearwardly by control louvers 18. It can be seen that the discharge of the fan air during level flight could cause distortion of the flow over the
 25 aerodynamic shape of wing 11. By providing recessed portions 17, the fan discharge may be then diffused to (remove the boundary layer and) substantially fill the recess to create, in effect an air wall and fill out the normal
 30 airfoil shape. Also, it should be noted that in order to reduce the drag of the relatively thick wing, which may be large in accommodating the fan, the forwardly directed inlet 14 in the leading edge of the wing serves a dual purpose. It provides an extra air inlet
 35 to provide a part of the large quantity of air needed in the hovering position as shown in Fig. 3, and it reduces the drag that would normally be associated with a thick wing by ducting part of the air through the wing instead of around it. It also permits smooth air
 40 flow during horizontal as shown in Fig. 4. By deflecting the air rearwardly and downwardly, as shown in Fig. 4, an increased amount of lift is obtained from the relatively thick wing. Thus, the forwardly directed inlet

reduces the drag loss that might normally be associated with such a large wing without the inlet. 50

WHAT WE CLAIM IS:—

1. A V.T.O.L. aircraft having a fuselage with wings extending therefrom, each wing
 55 being formed with a duct having a rearwardly extending portion provided with an air inlet in the leading edge of the wing and a louvered outlet in the lower surface of the wing, each
 60 duct having a driven fan disposed adjacent to the downstream end thereof, wherein each duct is formed with an additional louvered air inlet in the top surface of the wing, and wherein a recess is provided in each of the
 65 lower wing surfaces extending rearwardly from the duct outlet into which the respective ducts exhaust during horizontal flight when the louvered openings in the upper wing surface are closed and the louvers in the duct
 70 outlet deflect the fan exhaust rearwardly.

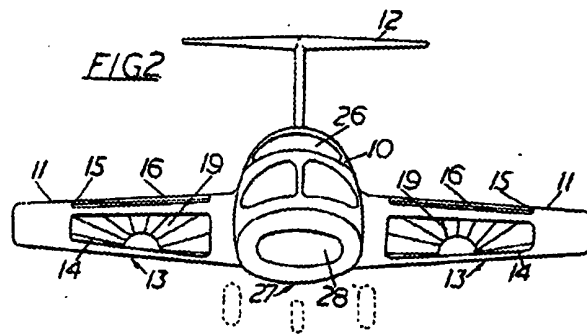
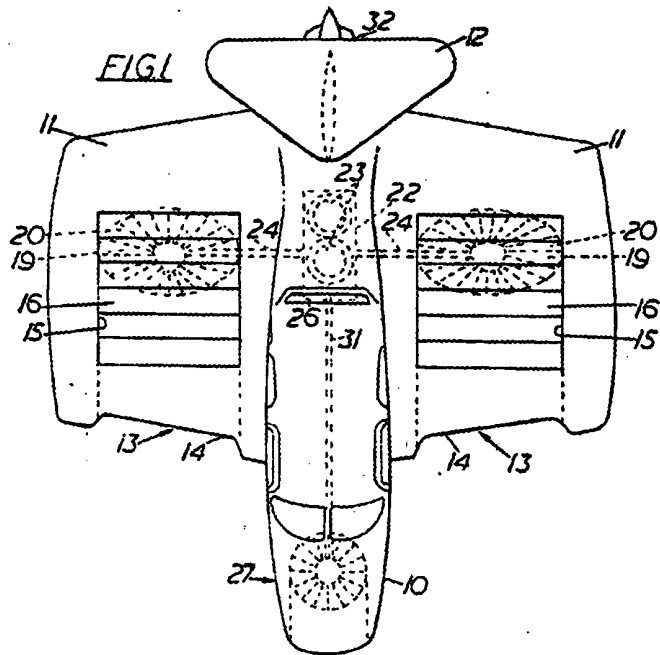
2. An aircraft according to claim 1, wherein reaction means is disposed in the fuselage at the tail of the aircraft to discharge fluid
 75 selectively to control yaw of the aircraft.

3. An aircraft according to claim 1 or 2, wherein a trim fan is disposed in the fuselage forwardly of the wing fan, to discharge
 80 air taken through an inlet in the fuselage leading surface, downwardly through an opening in the lower surface of the fuselage.

4. An aircraft according to any of the preceding claims, wherein fan driving means are provided in the form of gas turbine engine or engines located in the fuselage of the aircraft and coupled to the wing fans and trim
 85 fan.

5. A V.T.O.L. aircraft substantially as described with reference to and diagrammatically illustrated in the accompanying drawings.

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2 SHEETS This drawing is a reproduction of
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Fig 3

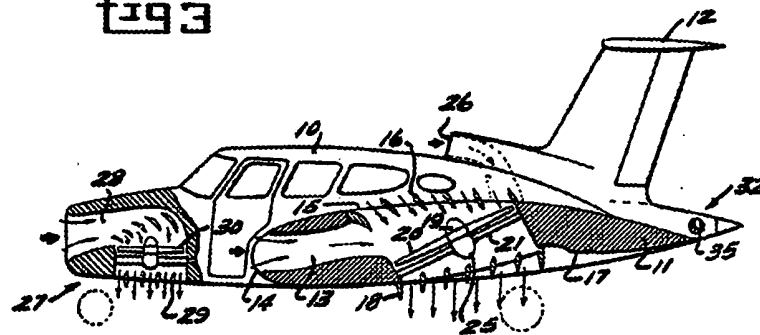
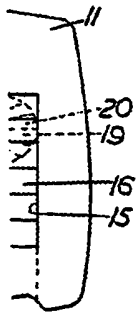


Fig 4

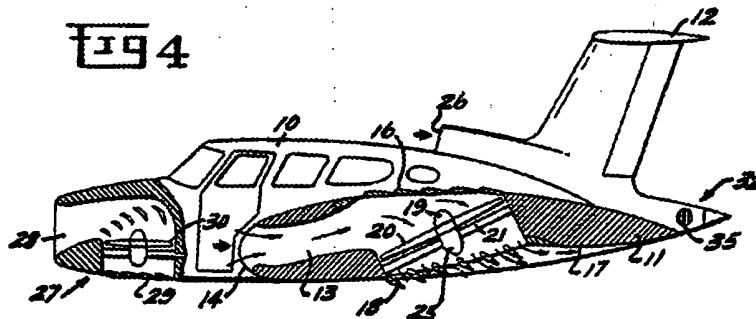
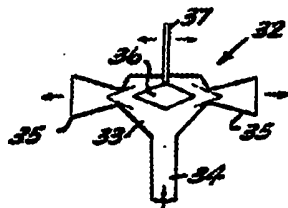


Fig 5



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